Appendix 15-B Preapproved Proprietary Wall/Reinforced Slope Design and Construction Review Checklist

Review tasks described in this appendix have not been specifically divided up between those tasks typically performed by the geotechnical reviewer and those tasks typically performed by the structural reviewer. The review tasks provided herein have been divided up relative to the various aspects of wall and reinforced slope design and construction.

Review contract plans, special provisions, applicable Standard Specifications, any contract addendums, the appendix to **WSDOT GDM Chapter 15** for the specific wall system proposed in the shop drawings, and **WSDOT GDM Appendix 15A** as preparation for reviewing the shop drawings and supporting documentation. Also review the applicable AASHTO design specifications and **WSDOT GDM Chapter 15** as needed to be fully familiar with the design requirements. If a HITEC report is available for the wall system, it should be reviewed as well.

The shop drawings and supporting documentation should be quickly reviewed to determine whether or not the submittal package is complete. Identify any deficiencies in terms of the completeness of the submittal package. The shop drawings should contain wall plans for the specific wall system, elevations, and component details that address all of the specific requirements for the wall as described in the contract. The supporting documentation should include calculations supporting the design of each element of the wall (i.e., soil reinforcement density, corrosion design, connection design, facing structural design, external wall stability, special design around obstructions in the reinforced backfill, etc., and example hand calculations demonstrating the method used by any computer printouts provided and that verify the accuracy of the computer output. The contract will describe specifically what is to be included in the submittal package.

The following geotechnical design and construction issues should be reviewed by the geotechnical designer when reviewing proprietary wall/reinforced slope designs (note that until the proprietary wall suppliers have fully converted to LRFD, LFD or working stress design may be used as an alternative to the LRFD requirements identified below in the checklist – see **WSDOT GDM Chapter 15, Appendix 15-A** for additional information on this issue):

1. External stability design
    a. Are the structure dimensions, design cross-sections, and any other requirements affecting the design of the wall assumed by the wall/reinforced slope supplier for the design consistent with the contract requirements? As a minimum, check wall length, top elevation (both coping and barrier, if present), finished ground line elevation in front of wall, horizontal curve data, and locations and size of all obstructions (e.g., utilities, drainage structures, sign foundations, etc.) in the reinforced backfill, if any are present.
    b. Has the correct, and agreed upon, design procedure been used (i.e., as specified in the WSDOT GDM, WSDOT LRFD BDM, and AASHTO LRFD Specifications or AASHTO Standard Specifications), including the correct earth pressures, earth pressure coefficients, and any other input parameters specified in the contract, both for static and seismic design?
    c. Has appropriate load group for each limit state been selected (in general, for LRFD, Service I should be used for the service limit state, Strength I should be used for the strength limit state, unless an owner specified vehicle is to be used, in which case Strength II should also be checked, and Extreme Event I should be used for the extreme event limit state – seismic design)?

d. Have the correct load factors been selected, both in terms of magnitude and for those load factors that have maximum and minimum values, has the right combination of maximum and minimum values been selected (see WSDOT BDM and the AASHTO LRFD Specifications)?

e. Has live load been treated correctly regarding magnitude (in general, approximated as 2 ft of soil surcharge load) and location (over reinforced zone for bearing, behind reinforced zone for sliding and overturning)?

f. Has the correct PGA, and k_h and k_v, been used for seismic design for external stability?

g. Have the correct resistance factors been selected for each limit state (see AASHTO LRFD Specifications), and is the wall stable against sliding, overturning (i.e., does it meet maximum eccentricity requirements)?

h. Have the correct soil properties been used in the analysis (reinforced zone properties and retained fill properties)?

i. Have the required external loads been applied in the analysis (external foundation loads, soil surcharge loads, etc.)?

j. Have minimum specified wall widths (i.e., AASHTO LRFD Specifications, WSDOT GDM, and WSDOT BDM specified minimum reinforcement lengths, and minimum reinforcement lengths specified to insure overall stability), in addition to those required for external and internal stability, been met in the final wall/reinforced slope design?

k. Does the wall embedment meet the minimum embedment criteria specified?

l. Are the maximum factored bearing stresses less than or equal to the factored bearing resistance for the structure for all limit states (service, strength, and extreme event)?

m. Has the computer output been hand checked to verify the accuracy of the computer program calculations (compare hand calculations to the computer output; also, a spot check calculation by the reviewer may also be needed if the calculations do not look correct for some reason)?

n. Have all special design requirements specified in the contract that are in addition to the GDM, BDM, and AASHTO LRFD Specification requirements been implemented in the supplier's design?

o. The following design issues should have already been addressed by geotechnical designer of record in the development of the contract requirements:

   i. Design parameters are appropriate for the site soil/rock conditions (see **WSDOT GDM Chapter 5**)

   ii. Wall is stable for overall stability and compound stability (service and extreme event limit states)

   iii. Settlement is within acceptable limits for the specific wall type(s) allowed by the contract (service limit state)

   iv. The design for any mitigating measures to provide adequate bearing resistance, overall stability, compound stability, to address seismic hazards such as liquefaction consistent with the policies provided in **WSDOT GDM Chapter 6** of the GDM, and to keep settlement within acceptable tolerances for the allowed wall or reinforced slope systems is fully addressed (service, strength and extreme event limit states)

   v. The design for drainage of the wall, both behind and within the wall, has been completed and is implemented to insure long-term drainage

p. Have the specific requirements and plan details relating to external stability specified in the sections that follow in this Appendix for the specific wall/reinforced slope system been used?

q. Have the design documents and plan details been certified in accordance with this manual?

2. Internal stability design
   a. Has the correct, and agreed upon, design procedure been used (i.e., as specified in the WSDOT GDM, WSDOT BDM, and AASHTO LRFD Specifications), including the correct earth pressures and earth pressure coefficients?
   b. Has appropriate load group for each limit state been selected (in general, the service limit state is not specifically checked for internal stability, Strength I should be used for the strength limit state, unless an owner specified vehicle is to be used, in which case Strength II should also be checked, and Extreme Event I should be used for the extreme event limit state – seismic design)?
   c. Have the correct load factors been selected (see WSDOT GDM, WSDOT BDM and the AASHTO LRFD Specifications)? Note that for reinforced slopes, since LRFD procedures are currently not available, load factors are not applicable to reinforced slope design.
   d. Has live load been treated correctly regarding magnitude (in general, approximated as 2 ft of soil surcharge load) and location (over reinforced zone for bearing, behind reinforced zone for sliding and overturning)?
   e. Have the effects of any external surcharge loads, including traffic barrier impact loads, been taken into account in the calculation of load applied internally to the wall reinforcement and other elements?
   f. Has the correct PGA been used for seismic design for internal stability?
   g. Have the correct resistance factors been selected for design for each limit state? For reinforced slopes, since LRFD design procedures are currently not available, check to make sure that the correct safety factors have been selected.
   h. Have the correct reinforcement and connector properties been used?
      i. For steel reinforcement, have the steel reinforcement dimensions and spacing been identified?
      ii. For steel reinforcement, has it been designed for corrosion using the correct corrosion rates, correct design life (75 years, unless specified otherwise in the contract documents)?
      iii. Have the steel reinforcement connections to the facing been designed for corrosion, and has appropriate separation between the soil reinforcement and the facing concrete reinforcement been done so that a corrosion cell cannot occur, per the AASHTO LRFD Specifications?
      iv. For geosynthetic reinforcement products selected, are the long-term design nominal strengths, T_{al}, used for design consistent with the values of T_{al} provided in the WSDOT Qualified Products List (QPL), if the products used in the wall/reinforced slope design are listed in the QPL? If the products are not listed in the QPL, or if installation conditions/backfill gradation or chemical properties do not meet the requirements specified herein, have the design T_{al} values been developed in accordance with WSDOT Standard Practice T925, including backup data to support the recommended values?
      v. Are the soil reinforcement - facing connection design parameters used consistent with the connection plan details provided? For steel reinforced systems, such details include the shear resistance of the connection pins or bolts, bolt hole sizes, etc. For geosynthetic reinforced systems, such details include the type of connection, and since the connection strength is specific to the reinforcement product (i.e., product material, strength, and type) – facing unit (i.e., material type and strength, and detailed facing unit geometry) combination, and the specific type of connector used, including material type and connector geometry, as well as how it fits with the facing unit. Check to make sure that the reinforcement – facing connection has been previously approved and that the approved design properties have been used.

vi. If a coverage ratio, R_c, of less than 1.0 is used for the reinforcement, and its connection to the facing, has the facing been checked to see that it is structurally adequate to carry the earth load between reinforcement connection points without bulging of facing units, facing unit distress, or overstressing of the connection between the facing and the soil reinforcement?

vii. Are the facing material properties used by the wall supplier consistent with what is required to produce a facing system that has the required design life and that is durable in light of the environmental conditions anticipated? Have these properties been backed up with appropriate supporting test data? Is the facing used by the supplier consistent with the aesthetic requirements for the project?

i. Check to make sure that the following limit states have been evaluated, and that the wall/reinforced slope internal stability meets the design requirements:
   i. Reinforcement resistance in reinforced backfill (strength and extreme event)
   ii. Reinforcement resistance at connection with facing (strength and extreme event)
   iii. Reinforcement pullout (strength and extreme event)
   iv. If K-Stiffness Method is used, soil failure at the strength limit state

j. If obstructions such as small structure foundations, culverts, utilities, etc., must be placed within the reinforced backfill zone (primarily applies to MSE walls and reinforced slopes), has the design of the reinforcement placement, density and strength, and the facing configuration and details, to accommodate the obstruction been accomplished in accordance with the WSDOT GDM, WSDOT BDM, and AASHTO LRFD Specifications?

k. Has the computer output for internal stability been hand checked to verify the accuracy of the computer program calculations (compare hand calculations to the computer output; also, a spot check calculation by the reviewer may also be needed if the calculations do not look correct for some reason)?

l. Have the specific requirements, material properties, and plan details relating to internal stability specified in the sections that follow in this Appendix for the specific wall/reinforced slope system been used?

m. Note that for structural wall facings for MSE walls, design of prefabricated modular walls, and design of other structural wall systems, a structural design and detail review must be conducted by the structural reviewer (for WSDOT, the Bridge and Structures Office conducts this review in accordance with the WSDOT BDM and the AASHTO LRFD Specifications).
   i. Compare preapproved wall details to the shop drawing regarding the concrete facing panel dimensions, concrete cover, rebar size, orientation and location. This also applies to any other structural elements of the wall (e.g., steel stiffeners for welded wire facings, concrete components of modular walls whether reinforced or not, etc.).
   ii. Is a quantity summary of components listed for each wall?
   iii. Do the geometry and dimensions of any traffic barriers or coping shown on shop drawings match with what is required by contract drawings (may need to check other portions of contract plans for verification (i.e. paving plans)? Has the structural design and sizing of the barrier/reaction slab been done consistently with the AASHTO specifications and WSDOT BDM? Are the barrier details constructable?
   iv. Do notes in the shop drawings state the date of manufacture, production lot number, and piece mark be marked clearly on the rear face of each panel (if required by special the contract provisions)?

3. Wall/slope construction sequence and requirements provided in shop drawings
   a. Make sure construction sequence and notes provided in the shop drawings do not conflict with the contract specifications (e.g., minimum lift thickness, compaction requirements, construction sequence and details, etc.). Any conflicts should be pointed out in the shop drawing review comments, and such conflicts should be discussed during the precon meeting with the wall supplier, wall constructor, and prime contractor for the wall/slope construction.
   b. Make sure any wall/slope corner or angle point details are consistent with the preapproved details and the contract requirements, both regarding the facing and the soil reinforcement. This also applies to overlap of reinforcement for back-to-back walls
4. Wall and reinforced slope construction quality assurance
   a. Discuss all aspects of the wall/slope construction and quality assurance activities at the wall/reinforced preconstruction meeting. The preconstruction meeting should include representatives from the wall supplier and related materials suppliers, the earthwork contractor, the wall constructor, the prime contractor, the project inspection and construction administration staff, and the geotechnical and structural reviewers/designers.
   b. Check to make sure that the correct wall or reinforced slope elements, including specific soil reinforcement products, connectors, facing blocks, etc., are being used to construct the wall (visually check identification on the wall elements). For steel systems, make sure that reinforcement dimensions are correct, and that they have been properly galvanized.
   c. Make sure that all wall elements are not damaged or otherwise defective.
   d. Make sure that all materials certifications reflect what has been shipped to the project and that the certified properties meet the contract/design requirements. Also make sure that the identification on the wall elements shipped to the site match the certifications. Determine if the date of manufacture, production lot number, and piece mark on the rear face of each panel match the identification of the panels shown on the shop drawings (if req. by special prov.).
   e. Obtain samples of materials to be tested, and compare test results to project minimum requirements. Also check dimensional tolerances of each wall element.
   f. Make sure that the wall backfill meets the design/contract requirements regarding gradation, ability to compact, and aggregate durability.
   g. Check the bearing pad elevation, thickness, and material to make sure that it meets the specifications, and that its location relative to the ground line is as assumed in the design. Also check to make sure that the base of the wall excavation is properly located, and that the wall base is firm.
   h. As the wall is being constructed, make sure that the right product is being used in the right place. For soil reinforcement, make sure that the product is the right length, spaced vertically and horizontally correctly per the plans, and that it is placed and pulled tight to remove any slack or distortion, both in the backfill and at the facing connection. Make sure that the facing connections are properly and uniformly engaged so that uneven loading of the soil reinforcement at the facing connection is prevented.
   i. Make sure that facing panels or blocks are properly seated on one another as shown in the wall details.
   j. Check to make sure that the correct soil lift thickness is used, and that backfill compaction is meeting the contract requirements.
   k. Check to make sure that small hand compactors are being used within 3 ft of the face. Reduced lift thickness should be used at the face to account for the reduced compaction energy available from the small hand compactor. The combination of a certain number of passes and reduced lift thickness to produce the required level of compaction without causing movement or distortion

to the facing elements should be verified at the beginning of wall construction. For MSE walls, compaction at the face is critical to keeping connection stresses and facing performance problems to a minimum. Check to make sure that the reinforcement is not connected to the facing until the soil immediately behind the facing elements is up to the level of the reinforcement after compaction. Also make sure that soil particles do not spill over on to the top of the facing elements.

l. Make sure that drainage elements are placed properly and connected to the outlet structures, and at the proper grade to promote drainage.

m. Check that the wall face embedment is equal to or greater than the specified embedment.

n. Frequently check to determine if wall face alignment, batter, and uniformity are within tolerances. Also make sure that acceptable techniques to adjust the wall face batter and alignment are used. Techniques that could cause stress to the reinforcement/facing connections or to the facing elements themselves, including shimming methods that create point loads on the facing elements, should not be used.

o. For reinforced slopes, in addition to what is listed above as applicable, check to make sure that the slope facing material is properly connected to the soil reinforcement. Also check that secondary reinforcement is properly placed, and that compaction out to the slope surface is accomplished.